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1                   1.    In combination for operating upon analog  
2   signals transmitted through a coaxial cable providing  
3   quadrature amplitude modulated data to recover the quadrature  
4   amplitude modulated data from noise and distortions in the  
5   coaxial cable,

6                   first means for converting the analog signals to  
7   corresponding digital signals,

8                   second means for operating upon the digital signals  
9   to provide the digital signals with a quadrature phase  
10   relationship,

11                  third means for passing the low frequency components  
12   in the digital signals with the quadrature phase relationship,  
13   and

14                  fourth means for derotating the digital signals  
15   passed by the third means to recover, in digital form, the  
16   quadrature amplitude modulated data from the noise and  
17   distortions in the coaxial cable.

1                   2.    In a combination as set forth in claim 1,  
2                   the fourth means including fifth means for  
3   multiplying the output from the third means by trigonometric  
4   signals in a quadrature phase relationship to provide for a  
5   recovery in digital form of the quadrature amplitude modulated  
6   data from the noise and distortions in the coaxial cable.

1                   3.    In a combination as set forth in claim 2,  
2                   sixth means for equalizing the derotated signals  
3   from the fourth means, and  
4                   seventh means responsive to the outputs from the,  
5   fourth means and the sixth means for providing a servo

6 feedback to the fourth means to adjust the phases of the  
7 trigonometric signals from the fifth means for facilitating  
8 the recovery of the quadrature amplitude modulated data by the  
9 fourth means from the noise and distortions in the coaxial  
10 cable.

1 4. In a combination as set forth in claim 3,  
2 means for obtaining the recovery of the phase and  
3 amplitude modulations in the coaxial cable at the output of  
4 the sixth means.

1 5. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data to recover the quadrature amplitude  
4 modulated data from noise in the coaxial cable,  
5 first means for converting the analog signals to  
6 corresponding digital signals,  
7 second means for operating upon the digital signals  
8 to provide a pair of the digital signals, one of the digital  
9 signals in the pair having a quadrature phase relationship to  
10 the other of the digital signals in the pair,  
11 third means for derotating the digital signals in  
12 the pair, and  
13 fourth means for equalizing the derotated signals  
14 from the third means.

1 6. In a combination as set forth in claim 5,  
2 fifth means responsive to the signals from the third  
3 means and the fourth means for servoing the operation of the  
4 third means to facilitate the derotation of the digital  
5 signals in the pair.

1                   7.    In a combination as set forth in claim 5,  
 2                   the signals in the coaxial cable including carrier  
 3 signals having a carrier frequency,  
 4                   fifth means for producing signals having a variable  
 5 frequency, and  
 6                   sixth means responsive to the signals from the  
 7 second means for varying the frequency of the signals from the  
 8 fifth means to provide a difference of a particular  
 9 intermediate frequency between the frequency of the carrier  
 10 signals and the frequency of the signals from the oscillator,  
 11 and  
 12                   seventh means responsive to the carrier signals in  
 13 the coaxial cable and the signals from the fifth means for  
 14 providing the signals at the particular intermediate  
 15 frequency.

1                   8.    In a combination as set forth in claim 7,  
 2                   means responsive to the signals from the first means  
 3 for regulating the gain of the analog signals converted by the  
 4 first means to the corresponding digital signals.

1                   9.    In combination for operating upon analog  
 2 signals transmitted through a coaxial cable using quadrature  
 3 amplitude modulated data to recover the quadrature amplitude  
 4 modulated data from noise and distortions in the coaxial  
 5 cable,  
 6                   first means for converting the analog signals to  
 7 digital signals,  
 8                   second means for operating upon the digital signals  
 9 to provide a pair of the digital signals, one of the digital  
 10 signals in the pair having a quadrature phase relationship,  
 11 with the other of the digital signals in the pair,

12                   third means for adjusting the phases of the digital  
13 signals in the pair to conform to the phases of the quadrature  
14 amplitude modulated signals in the coaxial cable, and

15                   fourth means responsive to the signals from the  
16 third means for providing a closed loop servo with the third  
17 means for locking the phases of the digital signals from the  
18 third means to the phases of the quadrature amplitude  
19 modulated signals in the coaxial cable.

1                   10. In a combination as set forth in claim 9,  
2                   the third means including means for derotating the  
3 digital signals in the pair.

1                   11. In a combination as set forth in claim 9,  
2                   the third means including a feed forward equalizer  
3 and a decision feedback equalizer and a pair of slicers each  
4 operable on an individual one of the digital signals in the  
5 pair to slice the digital signals into the closest of a number  
6 of binary values.

1                   12. In a combination as set forth in claim 11,  
2                   the third means including fifth means for derotating  
3 the digital signals in the pair,

4                   the fourth means being responsive to the derotated  
5 signals from the third means and to the digital signals from  
6 the slicers in the pair to lock the phases of the digital  
7 signals from the third means to the phases of the quadrature  
8 amplitude modulated signals in the coaxial cable.

1                   13. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data at a particular baud rate to recover

4 the quadrature amplitude modulated data from noise and  
5 distortions in the coaxial cable,

6 first means for converting the analog signals to  
7 digital signals at a variable rate,

8 second means for operating upon the digital signals  
9 to provide a pair of the digital signals, one of the digital  
10 signals in the pair having a quadrature phase relationship  
11 with the other of the digital signals in the pair,

12 third means for adjusting the phases of the digital  
13 signals in the pair to conform to the phases of the quadrature  
14 amplitude modulated signals in the coaxial cable, and

15 fourth means responsive to the signals from the  
16 third means for varying the rate of converting the analog  
17 signals to the digital signals to provide the digital signals  
18 at a rate having a particular relationship to the particular  
19 baud rate.

1 14. In a combination as set forth in claim 13,  
2 the third means including means for derotating the  
3 digital signals in the pair.

1 15. In a combination as set forth in claim 13,  
2 the third means including a feed forward equalizer  
3 and a decision feedback equalizer and a pair of slicers each  
4 operable on an individual one of the digital signals in the  
5 pair to slice the digital signals into the closest of a number  
6 of binary values.

1 16. In a combination as set forth in claim 15,  
2 the third means including fifth means for derotating  
3 the digital signals in the pair,

4 the fourth means being responsive to the derotated  
5 signals from the third means and to the digital signals from  
6 the slicers in the pair to lock the phases of the digital  
7 signals from the third means to the phases of the quadrature  
8 amplitude modulated signals in the coaxial cable.

1 17. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data on a carrier signal of a particular  
4 frequency to recover the quadrature amplitude modulated data  
5 from noise and distortions in the coaxial cable,

6 first means for converting the intermediate  
7 frequency analog signals in the receiver to digital signals at  
8 a variable rate,

9 second means for operating upon the digital signals  
10 to provide a pair of the digital signals, one of the digital  
11 signals in the pair having a quadrature phase relationship  
12 with the other of the digital signals in the pair,

13 third means for adjusting the phases of the digital  
14 signals in the pair to conform to the phases of the quadrature  
15 amplitude modulated signals in the coaxial cable,

16 fourth means for providing an oscillator having a  
17 variable frequency, the fourth means being disposed before the  
18 first means in the combination, and

19 fifth means responsive to the digital signals from  
20 the third means for varying the frequency of the oscillator to  
21 obtain the production, from the mixing of the analog signals  
22 and the oscillator signals, of intermediate frequency signals  
23 having a particular frequency.

1           18. In a combination as set forth in claim 17,  
2           the third means including means for derotating the  
3           digital signals in the pair.

1           19. In a combination as set forth in claim 17,  
2           the third means including a feed forward equalizer  
3           and a decision feedback equalizer and a pair of slicers each  
4           operable on an individual one of the digital signals in the  
5           pair to slice the digital signals into the closest of a number  
6           of binary values.

1           20. In a combination as set forth in claim 19,  
2           the third means including fifth means for  
3           derotating the digital signals in the pair,  
4           the fourth means being responsive to the derotated  
5           signals from the third means and to the digital signals from  
6           the slicers in the pair to lock the variable frequency of the  
7           oscillator to obtain the production, from the mixing of the  
8           analog signals and the oscillator signals, of intermediate  
9           frequency signals having a particular frequency.

1           21. In combination for operating upon analog  
2           signals transmitted through a coaxial cable using quadrature  
3           amplitude modulated data at a particular baud rate to recover  
4           the quadrature amplitude modulated data from noise and  
5           distortions in the coaxial cable,  
6           first means for converting the analog signals to  
7           digital signals at a variable rate,  
8           second means for operating upon the digital signals  
9           to provide a pair of the digital signals, one of the digital  
10          signals in the pair having a quadrature phase relationship,  
11          with the other of the digital signals in the pair,

12                   third means for adjusting the phases of the digital  
13 signals in the pair to conform to the phases of the quadrature  
14 amplitude modulated signals in the coaxial cable,

15                   fourth means responsive to the signals from the  
16 third means for providing a first closed loop servo with the  
17 third means for adjusting the operation of the first means to  
18 a rate having a particular relationship to the particular baud  
19 rate, and

20                   fifth means responsive to the signals from the third  
21 means for providing a second closed loop servo with the third  
22 means for locking the phases of the pair of the digital  
23 signals from the third means to the phases of the quadrature  
24 amplitude modulated signals in the transmitter.

1                   22. In a combination as set forth in claim 21,  
2                   the fourth means including a first digital-to-analog  
3 converter for converting the digital signals from the third  
4 means to corresponding analog signals for adjusting the  
5 operation of the first means to a rate having the particular  
6 relationship to the particular baud rate, and

7                   the fifth means including a second digital-to-analog  
8 converter for converting the digital signals from the third  
9 means to corresponding analog signals for locking the phases  
10 of the pair of the digital signals from the third means to the  
11 phases of the quadrature amplitude modulated signals in the  
12 coaxial cable.

1                   23. In a combination as set forth in claim 21,  
2                   means responsive to the digital signals from the  
3 first means for regulating the amplitude of the digital  
4 signals.



1                   24. In a combination as set forth in claim 21,  
2                   the quadrature amplitude modulated analog signals in  
3 the coaxial cable including carrier signals at a particular  
4 frequency, and  
5                   sixth means for providing signals having a variable  
6 frequency, and  
7                   seventh means responsive to the pair of the digital  
8 signals from the third means for varying the frequency of the  
9 signals from the sixth means to obtain, upon a mixture of the  
10 signals from the sixth means and the carrier signals,  
11 intermediate frequency signals having a particular frequency.

1                   25. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data at a particular carrier frequency to  
4 recover the quadrature amplitude modulated data from noise and  
5 distortions in the coaxial cable,  
6                   first means for converting the analog signals to  
7 digital signals,  
8                   second means for operating upon the digital signals  
9 to provide a pair of the digital signals, one of the digital  
10 signals in the pair having a quadrature phase relationship  
11 with the other of the digital signals in the pair,  
12                   third means for adjusting the phases of the digital  
13 signals in the pair to conform to the phases of the quadrature  
14 amplitude modulated signals in the coaxial cable,  
15                   fourth means responsive to the signals from the  
16 third means for providing a first closed loop with the third  
17 means for locking the phases of the pair of the digital  
18 signals from the third means to the phases of the quadrature  
19 amplitude modulated signals in the coaxial cable,

20 fifth means for providing signals having a variable  
21 frequency, and

22 sixth means responsive to the signals from the third  
23 means for providing a second closed loop with the third means  
24 for varying the frequency of the signals from the fifth means  
25 to obtain, upon a mixture of the signals at the carrier  
26 frequency and the signals having the variable frequency,  
27 intermediate frequency signals having a particular frequency.

1 26. In a combination as set forth in claim 25,  
2 the fourth means including a first digital-to-analog  
3 converter for converting the pair of the digital signals from  
4 the third means to corresponding analog signals for adjusting  
5 the operation of the third means to lock the phases of the  
6 pair of the digital signals from the third means to the phases  
7 of the quadrature amplitude modulated signals in the coaxial  
8 cable,

9 the sixth means including a second digital-to-analog  
10 converter for converting the digital signals from the third  
11 means to corresponding analog signals for locking the  
12 frequency of the signals from the fifth means relative to the  
13 carrier frequency for obtaining the intermediate frequency  
14 signals with a particular frequency.

1 27. In a combination as set forth in claim 25,  
2 means responsive to the analog signals from the  
3 first means for regulating the amplitude of the analog  
4 signals.

1 28. In a combination as set forth in claim 25,  
2 the third means including seventh means for  
3 derotating the digital signals in the pair and further

4 including eighth means for equalizing the derotated digital  
5 signals in the pair from the seventh means.

1 29. In a combination as set forth in claim 26,  
2 seventh means responsive to the analog signals from  
3 the first means for regulating the amplitude of the analog  
4 signals, and

5 the third means including eighth means for  
6 derotating the digital signals in the pair and further  
7 including ninth means for equalizing the derotated digital  
8 signals in the pair from the eighth means.

1 30. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data to recover the quadrature amplitude  
4 modulated data from noise and distortions in the coaxial  
5 cable,

6 first means for converting the analog signals to  
7 digital signals,

8 second means for operating upon the digital signals  
9 to provide a pair of the digital signals, one of the digital  
10 signals in the pair having a quadrature phase relationship  
11 with the other of the digital signals in the pair, and

12 third means for adjusting the phases of the digital  
13 signals in the pair to conform to the phases of the quadrature  
14 amplitude modulated signals in the coaxial cable, the third  
15 means including a feed forward equalizer and a decision  
16 feedback equalizer, the decision feedback equalizer including  
17 a pair of slicers each operable on an individual one of the  
18 digital signals in the pair to slice the digital signals into  
19 the closest of a number of binary values, the number being  
20 progressively increased with time.

1           31. In a combination as set forth in claim 30,  
2           the decision feedback equalizer having an output  
3           connected to the feed forward equalizer to control the  
4           operation of the feed forward equalizer in accordance with the  
5           operation of the decision feedback equalizer.

1           32. In a combination as set forth in claim 31,  
2           a second pair of slicers,  
3           the third means including a pair of adders each  
4           operative to receive the output of the decision feedback  
5           equalizer and the output of the feed forward equalizer and  
6           each operative to introduce its output to an individual one of  
7           the slicers in the second pair.

1           33. In a combination as set forth in claim 32,  
2           means responsive to the output from the third means  
3           for feeding the output back to the third means to facilitate  
4           the adjustment of the amplitudes and phases of the digital  
5           signals in the pair to conform to the amplitudes and phases of  
6           the quadrature amplitude modulated signals in the transmitter.

1           34. In combination for operating upon analog  
2           signals transmitted through a coaxial cable using quadrature  
3           amplitude modulated data to recover the quadrature amplitude  
4           modulated data from noise and distortion in the coaxial cable,  
5           first means for converting the analog signals to  
6           corresponding digital signals,  
7           second means for operating upon the digital signals  
8           to provide a pair of the digital signals, one of the digital  
9           signals in the pair having a quadrature phase relationship  
10          with the other of the digital signals in the pair,

11                   third means for adjusting the phases of the digital  
12 signals in the pair to conform to the phases of the quadrature  
13 amplitude modulated signals in the coaxial cable,  
14                   the third means including fourth means for  
15 derotating the phases of the digital signals in the pair and  
16 including fifth means for providing a feed forward  
17 equalization of the derotated digital signals in the pair and  
18 including sixth means for providing a decision feedback  
19 equalization of the signals from the fifth means.

1                   35. In a combination as set forth in claim 34,  
2                   means for feeding the signals from the sixth means  
3 back to the fifth means to enhance the feed forward  
4 equalization provided by the fifth means.

1                   36. In a combination as set forth in claim 34,  
2                   the decision feedback equalizer including a pair of  
3 slicers each operable on an individual one of the digital  
4 signals in the pair to slice the digital signals into the  
5 closest of a number of binary values, the number being  
6 progressively increased with time.

1                   37. In a combination as set forth in claim 36,  
2                   a pair of adders each operatively coupled to the  
3 feed forward equalizer and the decision feedback equalizer to  
4 operate upon one of the digital signals in the pair, and  
5                   a pair of additional slicers each operatively  
6 coupled to an individual one of the adders in the pair to  
7 provide an output of one of the digital signals in the pair  
8 without the noise and distortion in the coaxial cable.

1           38. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data to recover the quadrature amplitude  
4 modulated data from noise and distortion in the coaxial cable,

5           first means for converting the analog signals to  
6 corresponding digital signals,

7           second means for operating upon the digital signals  
8 to provide a pair of the digital signals, one of the digital  
9 signals in the pair having a quadrature phase relationship  
10 with the other of the digital signals in the pair,

11           third means for adjusting the phases of the digital  
12 signals in the pair to conform to the phases of the quadrature  
13 amplitude modulated signals in the coaxial cable,

14           the third means including fourth means for  
15 derotating the phases of the digital signals in the pair and  
16 including fifth means for equalizing the derotated digital  
17 signals in the pair.

1           39. In a combination as set forth in claim 37,  
2           means responsive to the derotated digital signals in  
3 the pair and to the equalized digital signals in the pair for  
4 operating upon the fourth means to facilitate the derotation  
5 of the digital signals in the pair by the fourth means.

1           40. In a combination as set forth in claim 37,

2           the quadrature amplitude modulated signals in the  
3 coaxial cable having a particular baud rate, and

4           means responsive to the derotated digital signals  
5 and to the equalized digital signals for operating upon the  
6 first means to obtain the conversion of the analog signals to  
7 the digital signals at a rate having a particular relationship  
8 to the particular baud rate.

1                   41. In a combination as set forth in claim 37,  
2                   the signals in the coaxial cable including carrier  
3 signals with a particular carrier frequency, and  
4                   an oscillator having a variable frequency, and  
5                   means responsive to the derotated digital signals  
6 and the equalized digital signals for varying the frequency of  
7 the oscillator to provide, upon a mixing of the analog signals  
8 and the signals from the oscillator, intermediate frequency  
9 signals having a particular frequency.

1                   42. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data to recover the quadrature amplitude  
4 modulated data from noise and distortions in the coaxial  
5 cable,

6                   first means for converting the analog signals to  
7 corresponding digital signals,

8                   second means for operating upon the digital signals  
9 to provide a pair of the digital signals, one of the digital  
10 signals in the pair having a quadrature phase relationship  
11 with the other of the digital signals in the pair,

12                  third means for adjusting the phases of the digital  
13 signals in the pair to conform to the phases of the quadrature  
14 amplitude modulated signals in the coaxial cable,

15                  the third means a sequential arrangement of a  
16 derotator, a feed forward equalizer and a decision feedback  
17 equalizer.

1                   43. In a combination as recited in claim 41,  
2                   means responsive initially to the outputs of the  
3 derotator and the decision feedback equalizer, and  
4                   subsequently to signals from the decision feedback equalizer,

5 for operating upon the derotator to facilitate the derotation  
6 of the phases of the digital signals in the pair.

1 44. In a combination as set forth in claim 41,  
2 the quadrature amplitude modulated signals in the  
3 coaxial cable having a particular baud rate, and  
4 means responsive to the outputs of the derotator and  
5 the decision feedback equalizer for operating upon the first  
6 means to obtain the conversion of the analog to the digital  
7 signals at a rate having a particular relationship to the  
8 particular baud rate.

1 45. In a combination as set forth in claim 41,  
2 the signals in the coaxial cable including carrier  
3 signals with a particular carrier frequency,  
4 an oscillator having a variable frequency, and  
5 means responsive initially to the outputs of the  
6 derotator and the decision feedback equalizer, and  
7 subsequently to signals the decision feedback equalizer, for  
8 varying the frequency of the oscillator to obtain, upon a  
9 mixing of the carrier signals and the signals from the  
10 oscillator, intermediate frequency signals having a particular  
11 frequency.

1 46. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulation data to recover the quadrature amplitude  
4 modulated data from noise and distortion in the coaxial cable,  
5 first means for converting the analog signals in the  
6 coaxial cable to corresponding digital signals,  
7 second means for operating upon the digital signals  
8 to provide a pair of the digital signals, one of the digital



9 signals in the pair having a quadrature phase relationship  
 10 with the other of the digital signals in the pair,  
 11 third means for adjusting the phases of the digital  
 12 signals in the pair to conform to the phases of the quadrature  
 13 amplitude modulated data in the coaxial line,  
 14 the third means including a feed forward equalizer  
 15 and a decision feedback equalizer and means for combining the  
 16 outputs of the feed forward equalizer and the decision  
 17 feedback equalizer to obtain resultant soft decisions and  
 18 including means for slicing the resultant decisions to obtain  
 19 the quadrature amplitude modulated data free from noise and  
 20 distortions.

1 47. In a combination as set forth in claim 46,  
 2 the decision feedback equalizer including an  
 3 additional slicer connected to receive the output of the  
 4 combining means and to provide, at progressive instants of  
 5 time, binary outputs of progressive sensitivity and including  
 6 means for determining any difference between the output of the  
 7 combining means and the binary outputs of progressive  
 8 sensitivity and including means for introducing the difference  
 9 determinations to the feed forward equalizer and decision  
 10 feedback equalizer to enhance the equalizing operation of the  
 11 feed forward equalizer and the decision feedback equalizer.

1 48. In a combination as set forth in claim 46,  
 2 means responsive to the outputs of the decision  
 3 feedback equalizer and the slicers for providing a closed loop  
 4 servo to enhance the operation of the third means in producing  
 5 the quadrature amplitude modulated data without noise and  
 6 distortions.

1                   49. In a combination as set forth in claim 46,  
2                   the quadrature amplitude modulated signals in the  
3 coaxial cable occurring at a particular baud rate, and  
4                   means responsive to the outputs of the derotator and  
5 the slicers for providing a closed loop servo to provide for  
6 the operation of the first means in converting the analog  
7 signals to the digital signals at a rate having a particular  
8 relationship to the particular baud rate.

1                   50. In a combination as set forth in claim 46,  
2                   the quadrature amplitude modulated signals in the  
3 coaxial cable having a particular carrier frequency, and  
4                   an oscillator having a variable frequency, and  
5                   means responsive to the outputs of the feed forward  
6 equalizer and the decision feedback equalizer for varying the  
7 frequency of the oscillator to provide, upon a mixing of the  
8 signals at the particular carrier frequency and the oscillator  
9 signals, intermediate frequency signals having a particular  
10 frequency.

1                   51. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data to recover the quadrature amplitude  
4 modulated data from noise and distortions in the coaxial  
5 cable,  
6                   first means for converting the intermediate analog  
7 signals to corresponding digital signals,  
8                   second means for operating upon the digital signals  
9 to provide a pair of the digital signals, one of the digital  
10 signals in the pair having a quadrature phase relationship  
11 with the other of the digital signals in the pair,

12                   third means for derotating the phases of the digital  
13 signals in the pair, and

14                   fourth means disposed in a symmetrical relationship  
15 to the derotated digital signals in the pair from the third  
16 means for equalizing the derotated digital signals in the  
17 pair.

1                   52. In a combination as set forth in claim 51,  
2                   means responsive to the signals from the third means  
3 and the fourth means for providing a closed loop servo for  
4 facilitating the derotation by the third means of the digital  
5 signals in the pair.

1                   53. In a combination as set forth in claim 51,  
2                   the quadrature amplitude modulated signals in the  
3 coaxial cable having a particular baud rate, and  
4                   means responsive to the signals from the third means  
5 and the fourth means for providing a closed loop servo for  
6 providing for the operation of the first means at a rate  
7 having a particular relationship to the particular baud rate  
8 in converting the analog signals in the coaxial cable to the  
9 corresponding digital signals.

1                   54. In a combination as set forth in claim 51,  
2                   the quadrature amplitude modulated signals in the  
3 coaxial cable having a particular carrier frequency,  
4                   an oscillator having a variable carrier frequency,  
5 and  
6                   means responsive to the signals from the third means  
7 and the fourth means for providing a closed loop servo for  
8 maintaining the oscillator at a frequency related to the  
9 particular carrier frequency,

10                   the oscillator being connected in the coaxial cable  
11 before the operation of the first means in converting the  
12 analog signals in the receiver to the corresponding digital  
13 signals.

1                   55. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data to recover the quadrature amplitude  
4 modulated data from noise and distortions in the coaxial  
5 cable,

6                   there being a plurality of stations each having an  
7 individual carrier frequency and each providing quadrature  
8 amplitude modulated signals in the coaxial cable,

9                   first means for converting the analog signals to  
10 corresponding digital signals,

11                   second means for operating upon the digital signals  
12 to provide a pair of the digital signals, one of the digital  
13 signals in the pair having a quadrature phase relationship  
14 with the other of the digital signals in the pair,

15                   third means for adjusting the phases of the digital  
16 signals in the pair to recover the quadrature amplitude  
17 modulated data from the noise and distortions in the coaxial  
18 cable, and

19                   fourth means responsive to the output from the third  
20 means for providing a closed loop servo with the third means  
21 for facilitating the recovery of the quadrature amplitude  
22 modulated data from the noise and distortions in the coaxial  
23 cable,

24                   the fourth means initially having a first response  
25 for a first period of time after switching from a first one of  
26 the stations in the plurality to a second one of the stations  
27 in the plurality to facilitate the recovery of an intermediate

28 frequency signal having a particular frequency from the  
29 carrier frequency of the second one of the stations in the  
30 plurality and subsequently having a second response after the  
31 first period of time to facilitate the recovery of the  
32 quadrature amplitude modulated data for the second one of the  
33 stations in the plurality from the noise and distortions in  
34 the coaxial cable.

1 56. In a combination as set forth in claim 55,  
2 the fourth means including means for converting the  
3 digital indications from the third means to analog signals for  
4 facilitating the recovery of the quadrature amplitude  
5 modulated data for the second one of the stations in the  
6 plurality from the noise and distortions in the coaxial cable.

1 57. In a combination as set forth in claim 55,  
2 the fourth means being responsive to the digital  
3 signals from the third means for adjusting the phases of the  
4 digital signals in the pair to facilitate the recovery of the  
5 quadrature amplitude modulated data for the second one of the  
6 stations in the plurality from the noise and distortions in  
7 the coaxial cable.

1 58. In a combination as set fort in claim 55,  
2 fifth means for providing an oscillator with a  
3 variable frequency,  
4 the fourth means being responsive to the digital  
5 signals from the third means for adjusting the frequency of  
6 the oscillator in the fifth means relative to the carrier  
7 frequency of the second one of the stations in the plurality  
8 to facilitate the recovery of the intermediate frequency  
9 signal with the particular frequency for the second one of the

10 stations in the plurality from the noise and distortions in  
11 the coaxial cable.

1 59. In a combination as set forth in claim 58,  
2 the intermediate frequency signals being sampled at  
3 a rate having a particular relationship to the particular baud  
4 rate,

5 the fourth means being responsive to the digital  
6 signals from the third means for adjusting, to a rate having a  
7 particular relationship to the particular baud rate, the  
8 operation of the first means in converting the analog signals  
9 to the digital signals.

1 60. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data to recover the quadrature amplitude  
4 modulated data from the noise and distortions in the coaxial  
5 cable,

6 first means for converting the analog signals in the  
7 coaxial cable to corresponding digital signals,

8 second means for operating upon the digital signals  
9 to provide a pair of the digital signals, one of the digital  
10 signals in the pair having a quadrature phase relationship  
11 with the other of the digital signals in the pair,

12 third means for adjusting the phases of the digital  
13 signals in the pair to recover the quadrature amplitude  
14 modulated data from the noise and distortions in the coaxial  
15 cable,

16 the third means including a feed forward equalizer,

17 the third means including slicer means operative  
18 upon the digital signals in individual ones of the pairs to  
19 conform such digital signals to the closest of individual ones

20 of a plurality of different levels, the slicer means being  
21 operative at successive periods of time to provide progressive  
22 numbers of levels in the plurality for conforming such digital  
23 signals,

24 means responsive to the outputs of the decision  
25 feedback equalizer and the slicer means for producing an error  
26 signal, and

27 means for feeding the error signal back to the feed  
28 forward equalizer and the decision feedback equalizer for  
29 adjusting the operation of the feed forward equalizer and  
30 decision feedback equalizer in accordance with such error  
31 signal.

1 61. In combination for operating upon analog  
2 signals transmitted through a coaxial cable using quadrature  
3 amplitude modulated data to recover the quadrature amplitude  
4 modulated data from the noise and distortions in the coaxial  
5 cable,

6 first means for converting the analog signals in the  
7 coaxial cable to corresponding digital signals,

8 second means for operating upon the digital signals  
9 to provide a pair of the digital signals, one of the digital  
10 signals in the pair having a quadrature phase relationship  
11 with the other of the digital signals in the pair,

12 third means for adjusting the phases of the digital  
13 signals in the pair to recover the quadrature amplitude  
14 modulated data from the noise and distortions in the coaxial  
15 cable,

16 the third means including a feed forward equalizer,

17 the third means including slicer means operative  
18 upon the digital signals in individual ones of the pairs to  
19 conform such digital signals to the closest of individual ones

20 of a plurality of different levels, the slicer means being  
21 operative at successive periods of time to provide progressive  
22 numbers of levels in the plurality for conforming such digital  
23 signals,

24 means responsive to the outputs of the decision  
25 feedback equalizer and the slicer means for producing an error  
26 signal, and

27 means for feeding the error signal back to the feed  
28 forward equalizer and the decision feedback equalizer for  
29 adjusting the operation of the feed forward equalizer and  
30 decision feedback equalizer in accordance with such error  
31 signal.

1 62. In a combination as set forth in claim 61,  
2 means responsive to the outputs of the decision  
3 feedback equalizer and the slicer means for combining such  
4 outputs, and

5 a pair of additional slicer means each responsive to  
6 the combined outputs of the decision feedback equalizer and  
7 the slicer means for providing the quadrature amplitude  
8 modulated data without the noise and distortions in the  
9 coaxial cable.

1 63. In a combination as set forth in claim 62,  
2 means responsive to the quadrature amplitude  
3 modulated data in the third means and the quadrature amplitude  
4 modulated data from the additional slicer means for feeding  
5 signals back to the third means to facilitate the recovery of  
6 the quadrature amplitude modulated data by the third means.



1                   64. In a combination as set forth in claim 60,  
2                   the analog signals occurring at a particular baud  
3                   rate, and  
4                   means responsive to the quadrature amplitude  
5                   modulated data in the third means and the quadrature amplitude  
6                   modulated data from the additional slicer means for  
7                   controlling the operation of the first means to provide for  
8                   the conversion of the analog signals to the digital signals at  
9                   a rate having a particular relationship to the particular baud  
10                  rate.

1                   65. In a combination as set forth in claim 62,  
2                   there being a carrier signal at a particular  
3                   frequency for the quadrature amplitude modulated signals in  
4                   the coaxial cable,  
5                   an oscillator having a variable frequency, and  
6                   means responsive to the quadrature amplitude  
7                   modulated data in the third means and the quadrature amplitude  
8                   modulated data from the additional slicer means for varying  
9                   the frequency of the oscillator to obtain, from a mixing of  
10                  the carrier signal and the signal from the local oscillator,  
11                  an intermediate frequency signal having a particular  
12                  frequency.

1                   66. In combination for operating upon analog  
2                   signals transmitted through a cable using quadrature amplitude  
3                   modulated data to recover the quadrature amplitude modulated  
4                   data from the noise and distortions in the coaxial cable,  
5                   there being a plurality of stations each having an  
6                   individual carrier frequency and each providing quadrature  
7                   amplitude modulated signals in the coaxial cable,

8 first means for converting the analog signals in the  
 9 coaxial cable to corresponding digital signals,  
 10 second means for operating upon the digital signals  
 11 to provide a pair of the digital signals, one of the digital  
 12 signals in the pair having a quadrature phase relationship  
 13 with the other of the digital signals in the pair,  
 14 third means for adjusting the phases of the digital  
 15 signals in the pair to recover the quadrature amplitude  
 16 modulated data from the noise and distortions in the coaxial  
 17 cable, and  
 18 fourth means responsive to the indications from the  
 19 first means for regulating the gain of the analog signals  
 20 before the conversion of the analog signals to the digital  
 21 signals by the first means, the fourth means having a first  
 22 response for a first period of time after switching from a  
 23 first one of the stations in the plurality to a second one of  
 24 the stations in the plurality and subsequently having a second  
 25 response after the first period of time to facilitate the  
 26 recovery of the quadrature amplitude modulated data for the  
 27 second one of the stations in the plurality from the noise and  
 28 distortions in the coaxial cable.

1 67. In a combination as set forth in claim 64,  
 2 the fourth means being responsive to every digital  
 3 conversion by the first means for the first period of time and  
 4 being responsive to every nth conversion by the first means  
 5 after the first period of time where n is an integer greater  
 6 than 1.

1 68. In a combination as set forth in claim 66,  
 2 the fourth means including means for converting the  
 3 digital indications from the first means to analog indications

4 for regulating the gain of the analog signals in the coaxial  
5 cable.

1 69. In a combination as set forth in claim 66,  
2 the analog signals having a particular baud rate,  
3 and

4 means for regulating the rate of conversion by the  
5 first means of the analog signals to the digital signals to  
6 correspond to a rate having a particular relationship to the  
7 baud rate of the analog signals.

1 70. In a combination as set forth in claim 66,  
2 the analog signals having a particular carrier  
3 frequency,

4 an oscillator having a variable frequency,  
5 means for mixing the signals from the oscillator  
6 with the analog signals in the coaxial cable before the  
7 conversion of the analog signals to the digital signals by the  
8 first means, and

9 means for regulating the variable frequency of the  
10 oscillator to obtain from the mixing an intermediate frequency  
11 signal having a particular frequency.

1 71. In combination for acting upon analog signals  
2 transmitted through a cable using quadrature amplitude  
3 modulated data to recover the quadrature amplitude modulated  
4 data from the noise and distortions in the coaxial cable,

5 first means for converting the analog signals in the  
6 coaxial cable to corresponding digital signals,

7 second means for operating upon the digital signals  
8 to provide a pair of the digital signals, one of the digital

9 signals in the pair having a quadrature phase relationship  
10 with the other of the digital signals in the pair,

11 third means for adjusting the phases of the digital  
12 signals in the pair to recover the quadrature amplitude  
13 modulated data from the noise and distortions in the coaxial  
14 cable,

15 the third means including a feed forward equalizer  
16 and a decision feedback equalizer connected to receive the  
17 output of the feed forward equalizer and including means for  
18 feeding the output of the decision feedback equalizer to the  
19 feed forward equalizer to regulate the operation of the feed  
20 forward equalizer in adjusting the amplitudes and phases of  
21 the digital signals in the pair to recover the quadrature  
22 amplitude modulated data from the noise and distortions in the  
23 coaxial cable.

1 72. In a combination as set forth in claim 71,  
2 means for adding the outputs of the feed forward  
3 equalizer and the decision feedback equalizer, and

4 means responsive to the outputs of the adding means  
5 for providing the quadrature amplitude modulated data without  
6 the noise and distortions in the coaxial cable.

1 73. In a combination as set forth in claim 71,  
2 the decision feedback equalizer having a pair of  
3 slicers each operative to provide outputs of increased  
4 sensitivity at progressive instants of time and including  
5 means responsive to the outputs of the slicers and the outputs  
6 of the decision feedback equalizers for producing error  
7 signals for regulating the operation of the feed forward  
8 equalizer and decision feedback equalizer.

1                   74. In a combination as set forth in claim 73,  
2                   a second pair of slicers responsive to the outputs  
3                   of the feed forward equalizer and the decision feedback  
4                   equalizer for combining these outputs to obtain the quadrature  
5                   amplitude modulated data without the noise and distortions in  
6                   the coaxial cable.

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